Catalytic Converters for Cleaner Vehicles

U.S. DEPARTMENT OF ENERGY

OFFICE OF TRANSPORTATION TECHNOLOGIES

Transportation

FOR THE 21ST CENTURY

Background

To date, the development and commercialization of the catalytic converter has led to greater reductions in vehicular emissions than any other innovation. Catalytic converters simultaneously convert high percentages of carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NO_x) into less harmful by-products. The catalytic converter was derived in part from the technology of the ceramic regenerator, or heat exchanger, developed by the Energy Research and Development Administration (ERDA; The U.S. Department of Energy's predecessor) to increase the efficiency of gas turbine engines. More recently, researchers at the National Renewable Energy Laboratory (NREL) have developed insulation techniques to enable the catalytic converter to "light off" more quickly which reduces emissions during vehicle start up.

The Technology

Fueled by the need to meet stringent emissions standards, U.S. auto manufacturers approached Corning, Inc. in the early 1970s to develop an emissions reduction system, or catalytic converter. Corning successfully developed a ceramic substrate on which to apply catalysts used to convert the undesirable engine exhaust emissions. However, a critical hurdle still remained in developing a method to optimize exhaust flow over the catalyst to increase conversion efficiency. It was soon realized that technology from ERDA's ceramic regenerator could be used to provide the airflow structure for the catalytic converter. Like the ceramic regenerator, the catalytic converter required a structure optimized to provide the maximum surface area per unit volume. In addition, the low cost manufacturing techniques developed for the ceramic regenerator were applicable to the catalytic converter structure. As such, technology from the ceramic regenerator was key to the development of the first catalytic converter—the basis of 95% of today's automotive catalytic converters. Catalytic converters do not perform effectively until reaching an operating temperature of almost 600ºF known as "lightoff." Consequently, 60% to 80% of all vehicle emissions occur during startup while the catalytic converter is heating. To solve the problem, Benteler Industries Inc., and NREL developed technologies in 1996 to insulate the catalytic converter in order to maintain an effective operating temperature for up to 24 hours after the engine is turned off. NREL's efforts focused on three technological innovations: 1) compact vacuum insulation to keep heat from escaping; 2) phase-change materials to absorb, store, and release heat as needed; and 3) variable-conductance insulation to prevent overheating by automatically turning the insulation system off when the catalytic converter becomes too hot. In recent tests on a Ford Taurus at Southwest Research Institute, the new insulator technology cut CO and HC emissions during startup by 93% and 84%, respectively.

Commercialization

The installation of a catalytic converter reduces CO and HC emissions by more than 90% and NO_x emissions by up to 70%. In 1998, catalytic converters decreased emissions of CO and HC by 20 million and 2 million tons, respectively, and converted one million tons of NO_x into less harmful by-products. The use of NREL's new insulator technology today would further lower CO and HC emissions annually by two million tons and 175,000 tons, respectively. To date, the catalytic converters have been used on more than 300 million automobiles, which have logged a total of 2.5 billion years of combined service without a single recall.

Benefits

- **In 1998, catalytic converters reduced automotive emissions by**

  20 million tons of CO
  2 million tons of HC
  1 million tons of NO_x

- **NREL's insulation technology can annually save an additional**

  2 million tons of CO
  175,000 tons of HC

For more information on how DOE is helping America remain competitive in the 21st century, please contact:

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